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GAIN STABILITY MEASUREMENT TECHNIQUES FOR CALORIMETER PHOTOTUBES

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INTRODUCTION

Gain variation in phototubes may occur as a result of many factors. Some of these are: time[2], temperature,[15,22] magnetic field[2], counting rate[3,4,6,9] and several others which are hard to predict and control[6,7,16,17].

Because of these gain variations, it may be necessary to test each phototube which is anticipated for use in a calorimeter in order to reject those whose gain shift would result in insufficiently accurate results.

TESTING METHODS

It has been noted by other observers[9] that two components of gain shift manifest themselves: (1) a long term gradual shift in gain, and (2) an immediate shift when the tube is first subjected to high counting rates. With this in view, two separate testing methods were set up to investigate gain shift.

TEST SET UP

Figure 1 shows a block diagram of the long term method. A chopped DC light (1 second on, 4 seconds off) was arranged to illuminate a pair of phototubes mounted in an enclosure (dark box). The light repetition rate and duty cycle were chosen to closely match the actual operating conditions to which the phototubes would be subjected in the beam at the Fermi National Accelerator Laboratory. One of the tubes was so connected and biased that it was a photodiode and merely collected the initial photoelectrons (gain of 1). Its use was that of a monitor to record and display the long term light stability. The second tube (the one under test) saw the same light source greatly attenuated by neutral density filters. The two phototubes drove parallel inputs on a dual track chart recorder to enable long term measurements of the tube under test. Any drift of the light source is recorded by the photodiode and the photomultiplier data may be renormalized via the diode data. Several runs were made at various selected light levels thus enabling the photomultiplier to be "exercised" over a range of average anode currents.

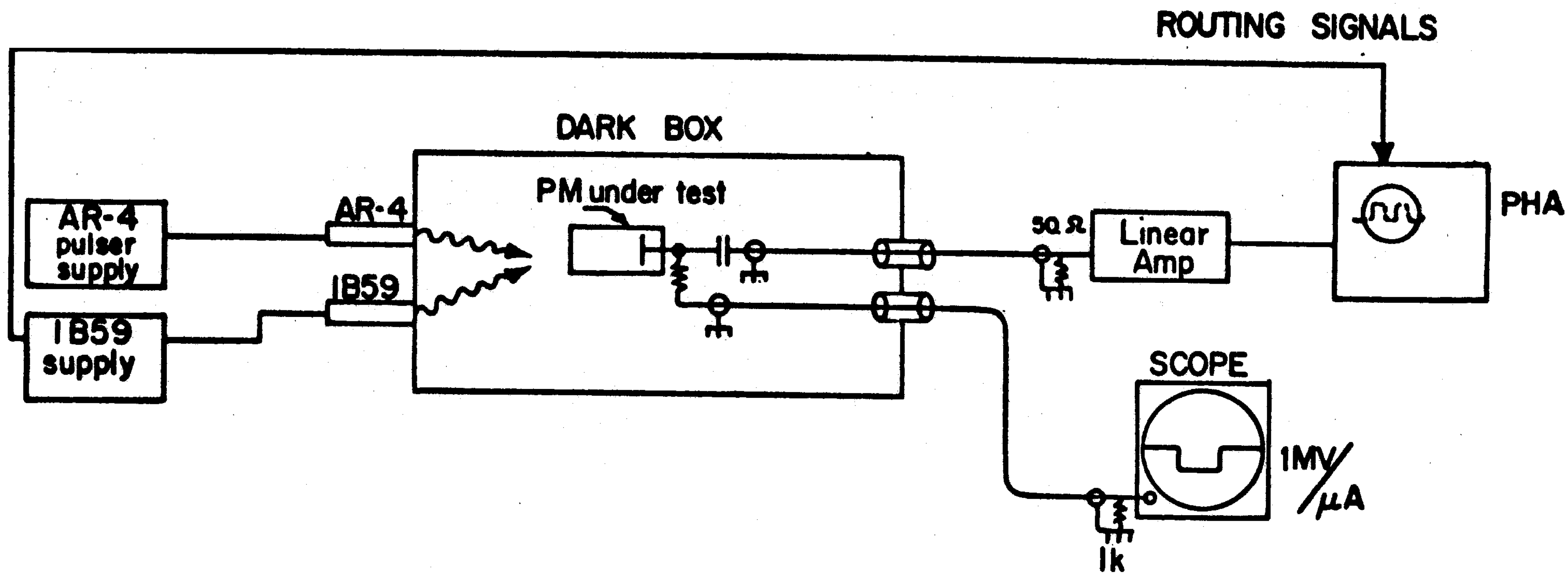
Figure 2 shows a block diagram of a different arrangement which records the immediate gain shifts over a range of various light levels. In this test, two light sources were simultaneously directed at the phototube under test. The previously described (on 1 sec. off 4 sec.) light source was used to adjust the phototube average anode current thus simulating various counting rates to which the phototube may be exposed. In addition, a fast, stable light pulser was flashed at the phototube. From the test set up diagram (Fig. 2) one sees that the phototube output is split into two components. The fast pulse component is capacitively coupled and terminated into a linear amplifier to drive a pulse height analyzer. The other component is directly coupled, to complete the DC path. A 1K termination at the scope provides the convenient transfer function of one Millivolt/microamp of average anode current from the phototube.

The external routing feature of the PHA is utilized to allow the pulses collected during "1 sec. light on time" to be stored in a different quadrant of memory than those pulses collected during "4 sec. light off". Thus the two spectra collected may be superimposed for inspection of gain shift as seen in Fig. 3.

RESULTS

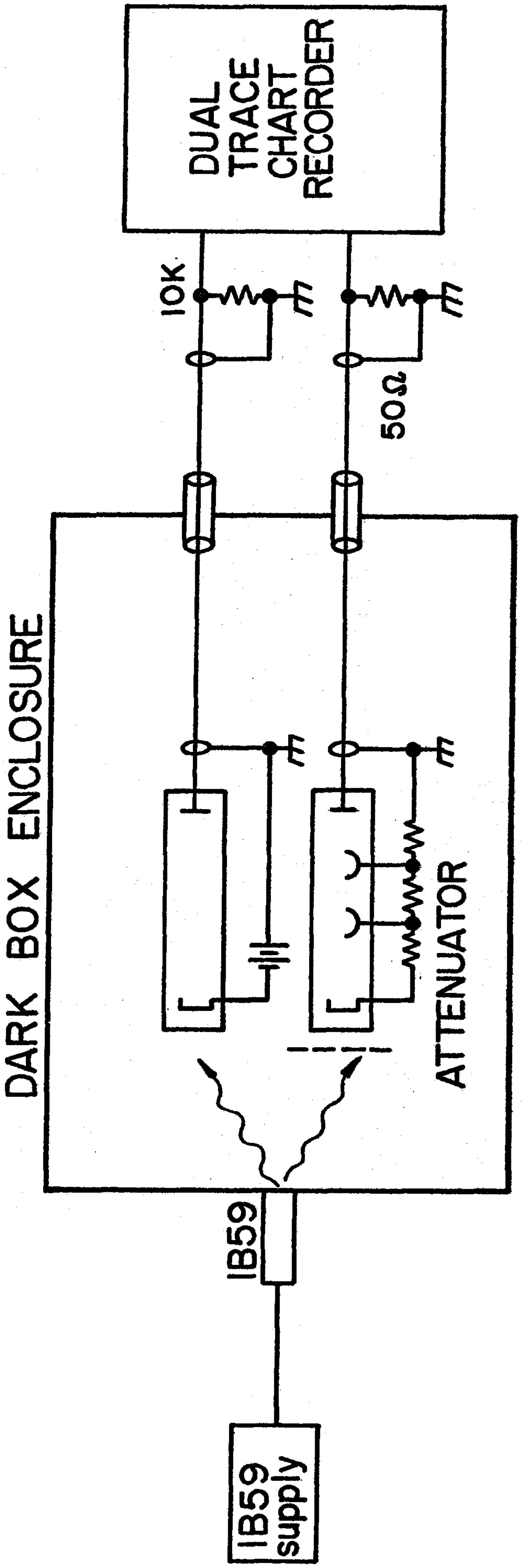
Data was recorded for 5 different RCA 6342A phototubes. Test results of these tubes are shown in Fig. 4. No attemps were made to separate the various possible drift sources.

In addition, one tubes data was recorded at two different gain settings (6×10^5 and 1.5×10^5) with light levels adjusted to achieve the same selected anode currents, i.e., the gain was dropped a factor of 4 and the light level increased a factor of 4. Test results of this "gain change run" are shown in Fig. 5.



PHOTOTUBE GAIN STABILITY TEST SETUP

Fig. 1



LONG TERM STABILITY TEST SETUP

Fig. 2

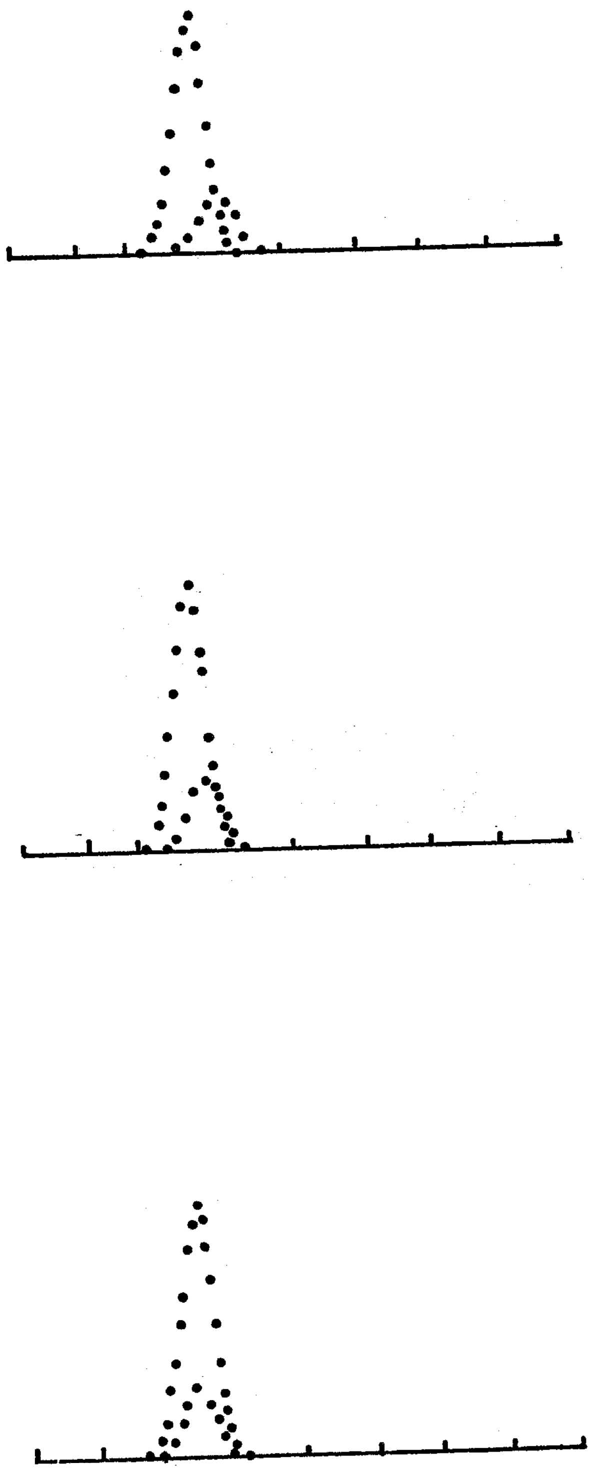


Fig. 3

Fig. 4

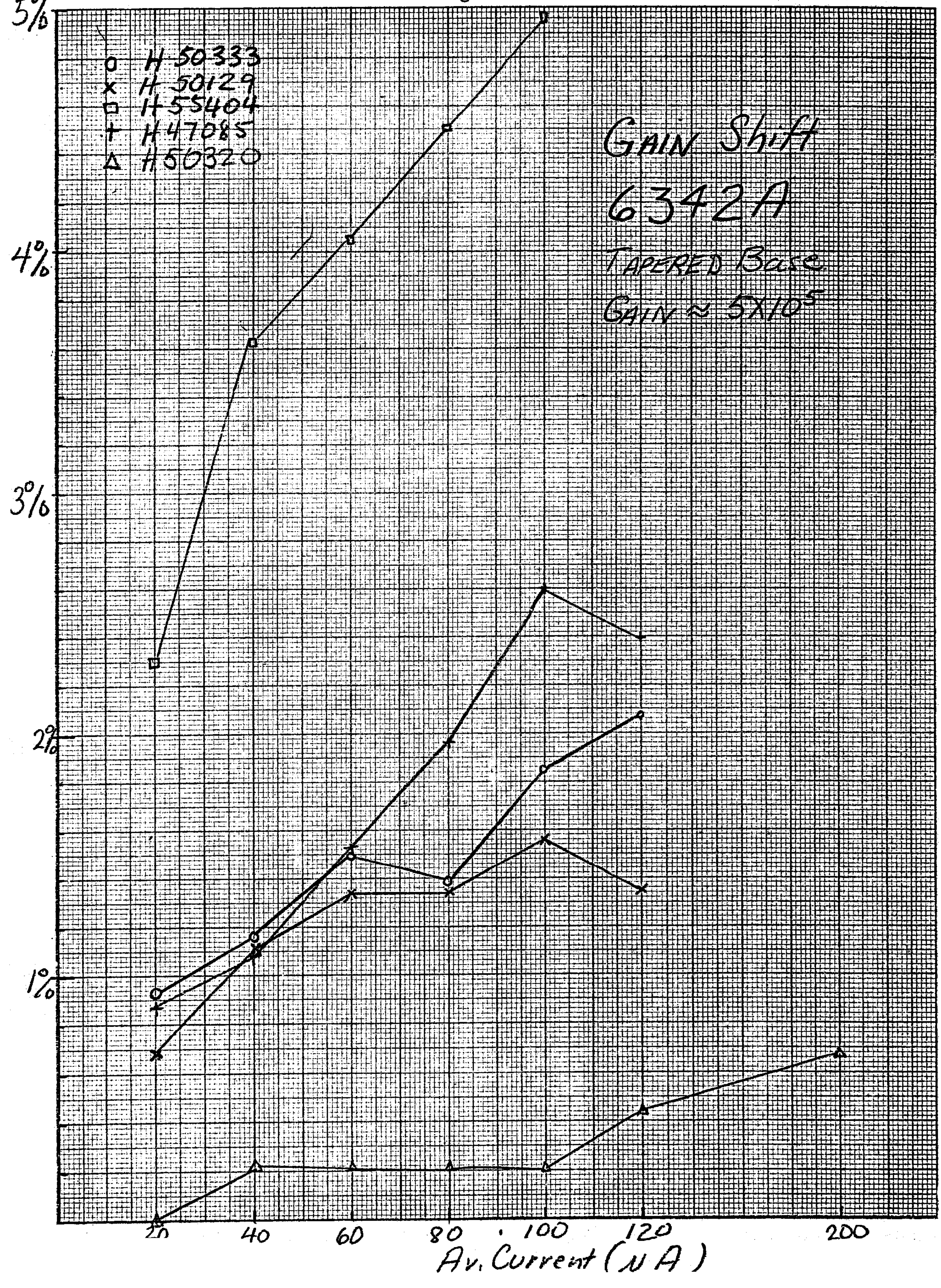
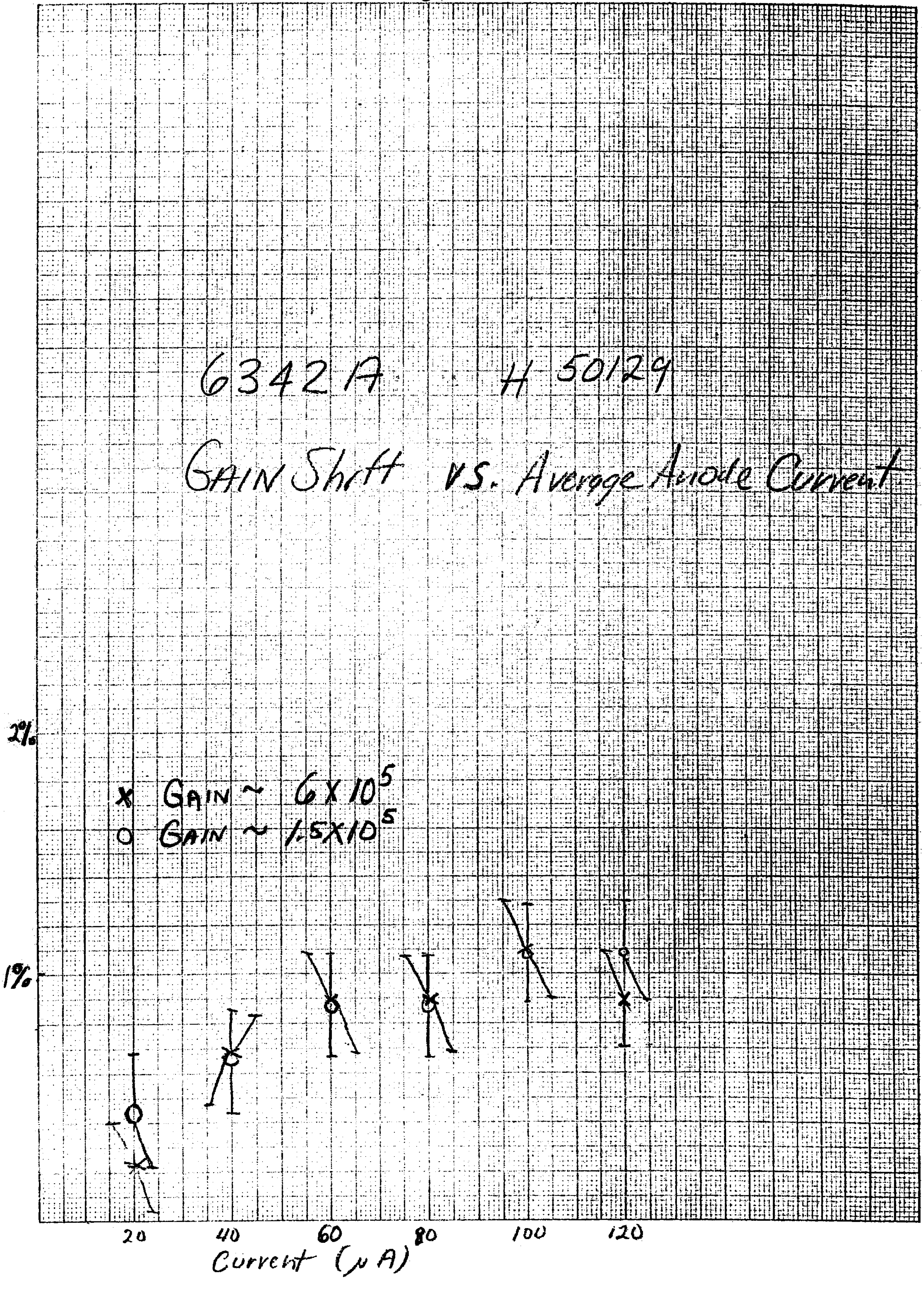

5%
4%
3%
2%
1%
○ H 50333
× H 50129
□ H 55404
+ H 47085
△ H 56320
GAIN Shift
6342A
TAPERED Base
GAIN ≈ 5X10^5
20
40
60
80
100
120
200
Av. Current (μA)

Fig. 5


6342 A H 50129
GAIN Shift VS. Average Anode Current
x GAIN ~ 6 X 10^5
o GAIN ~ 1.5 X 10^5
2%
1%
20
40
60
80
100
120
Current (µA)

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